AUDIO SYSTEM RESPONSIVE TO INCOMING PHONE CALLS

BACKGROUND

1. Field of the Present Invention

The present invention is in the field of electronic equipment for use in conjunction with audio systems such as an audio system in a motor vehicle.

2. History of Related Art

People in general and business professionals in particular spend a significant amount of time in their motor vehicles. During much of this time, many people use their audio systems for listening to radio, CD's, books on tape, and the like. Simultaneously, cellular telephone and wireless paging services are now so pervasive that a large percentage of vehicles on the road have one or more cellular telephones and/or wireless pagers in them all or most of the time and many business professionals now routinely conduct business using their cell phones while driving in their own vehicles or riding in colleagues' vehicles.

A problem arises when a wireless device such as a cellular phone and/or wireless pager device that is inside a vehicle rings or is otherwise activated while the vehicle's audio system is on. The owner of the ringing or beeping wireless device may not hear the tone at all or in time to respond to it after turning the audio system down or off. Perhaps as significant, safety issues may be raised when a driver reacts to an incoming call or page by quickly turning his or her attention to the audio system in an effort to answer the call promptly without subjecting the caller to the driver's personal listening preferences. It would be desirable to implement a system in which audio systems and cellular telephones cooperate to prevent, as desired, simultaneous use of both.

SUMMARY OF THE INVENTION

The problem identified above is addressed by a system and a motor vehicle according to the present invention. The motor vehicle includes an audio system and a control system configured to mute the audio system output automatically in response to input signals indicating

an incoming call on an authorized or recognized cell phone or pager. The incoming call may be detected in various ways. A digital input implementation employs a wire or cable connecting the wireless device directly to a digital input port of the control system. The cable carries a signal that is asserted whenever an incoming call is detected. An audio input implementation uses a set of audio detectors throughout the vehicle. The control system is "trained" to listen for a wireless device ring that matches any of a list of previously learned cell phone rings. The control system may support infrared and radio frequency implementations as well. In another embodiment, the control system detects the incoming call through the motor vehicle's external antenna in parallel with the detection of the incoming call by the wireless device. In any of these implementations, the control system is configured to assert a mute signal upon detecting an incoming call to a recognized or authorized wireless device.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention will become apparent upon reading the following detailed description and upon reference to the accompanying drawings in which:

FIG 1 is a diagram of a motor vehicle according to one embodiment of the invention for muting the audio system in response to an incoming call to a wireless device;

FIG 2 is a circuit diagram of selected elements of the motor vehicle of FIG 1; and

FIG 3 is a logic diagram of selected elements of the motor vehicle of FIG 1.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that the drawings and detailed description presented herein are not intended to limit the invention to the particular embodiment disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the present invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

Generally speaking, the present invention contemplates an audio system, such as the audio system present in most motor vehicles, which responds to selected incoming wireless

device signals by muting or otherwise altering the audio system's playing mode. When an incoming signal to a wireless device is detected, the audio system responds by muting the audio system thereby preventing the motor vehicle occupant from having to manually adjust the audio system volume. The disclosed audio system thereby provides a significant automation and safety feature to the motor vehicle.

Turning now to the drawings, FIG 1 illustrates selected elements of a motor vehicle **100** having an audio system **102**, according to an embodiment of the present invention, that is designed and enabled to respond to the detection of various signals or stimuli by automatically muting the audio system output. The invention is intended to encompass implementations using a variety of different stimulus, examples of which are envisioned by the depicted implementation. More specifically, the invention is intended to include implementations that rely on radio frequency signals, audio signals, infrared signals, and digital signals as the trigger that initiates the muting of the audio system. The illustrated example of motor vehicle **100** includes devices to handle all of these different types of signals. In other implementations, cost savings may be realized by including hardware capable of handling just one or a few of these types of signals. In the following text, the depicted wireless device used in conjunction with the present invention is a cellular telephone. The invention, however, is applicable for use with wireless communication devices generally. Such devices include, for example, wireless pagers as well as personal digital assistants (PDA's) and pocket PC's having wireless capabilities.

As depicted in FIG 1, motor vehicle **100** includes an audio system **102** that drives one or more speakers **104**. A control system **110** is configured to assert a mute signal **105** that is provided to the audio system under prescribed circumstances. In addition, control system **110** includes a set of signal input ports **112**, **114**, **116**, and **118**, for receiving various types of input signals from two or more wireless communication devices, each of which may result in the assertion of mute signal **105**. Other embodiments of the invention may include a control system **110** having any one or any combination of the signal input ports **112** through **118**.

A first signal input port **112**, referred to herein as the digital input port, is shown as connected to a cradle **122** via an intermediate cable or wire. Cradle **122** is designed to receive a cellular or wireless telephone **120**. Cradle **122** is typically a phone specific cradle that is sized to and includes connectors for the specific make and model of phone **120**. Phone **120**, in an embodiment suitable for use with digital input port **112**, is configured to assert an externally

accessible signal when an incoming call to the cellular telephone is received and, perhaps, during the time when the ensuing conversation is in progress. Cradle **122** includes a connector that contacts the externally accessible phone signal and conveys the externally accessible phone signal to digital input port **112** over the intermediate cable or wire. Control system **110** includes logic or other means to assert mute signal **105** in response to the assertion of the signal provided to digital input port **112**. The signal provided to digital signal input port **112**, in various embodiments, is a digital signal that may include a single bit or multiple bits of information. In a single bit implementation (desirable for its ease of implementation and cost), the digital input port is designed to interpret the signals as a switch signal for mute signal **105**. In multiple bit implementations, the digital input port **112** may receive additional information provided by the phone **120**. This information could include, for example, the caller's phone number and other information that may be used to make decisions about whether to assert mute signal **105** (e.g., mute audio system depending upon the caller's identity). At a minimum, however, control system **110** is designed to respond to the signal received by digital input port **112** by generating mute signal **105** to adjust or mute the audio output produced by audio system **102**.

Control system **110** as depicted in FIG 1 also includes an audio input port **114**. Audio signal input port **114** is shown as connected to a set of audio detectors (e.g., microphones) **130**. Audio detectors **130** may be placed within the vehicle **100** in position most likely to be in proximity to a ringing or beeping cell phone or pager. Thus, as an example, an audio detector **130** may be positioned within or near each seat **132** of the vehicle. In the audio input embodiment, a user of the system would likely have to train or teach audio system **110** the sound to which it should respond by muting the radio. The user would have to transition control system **110** to a learn mode by, for example, pressing a predetermined sequence of numbers using audio system's "channel" buttons. After successfully placing the control system **110** in learn mode, the user would then place the phone near one of the audio detectors and force the phone to ring as it would ring in response to an incoming call. Control system **110** receives the audio signal via an audio detector **130** through input port **114**, converts it to a digital format, and stores the digital representation of the ringing cell phone. When not in learn mode, control system **110** is configured to use digital signal processing (DSP) techniques to compare the sounds received via audio inputs **130** to the sound of the ringing cell phone. If a match is detected between sound received via audio input port **114** and the stored representation of the ringing cell phone, the

control system **110** would respond by asserting mute signal **105** to mute or alter the audio system output.

Infrared signal input port **116** and radio frequency signal input port **118** are configured for use with an infrared signal generator and a radio frequency signal generator of phone **120**. In response to receiving an incoming call, cell phone **120** may generate an infrared signal such as an IrDA compliant signal or a short range (i.e., less than approximately 50 meters) radio frequency signal such as a Bluetooth® or WiFi (IEEE 802.11) compliant signal. These signals are received by infrared signal input port **116** and radio frequency signal input port **118** through sensors **124** and **128**. respectively. Control system **110** responds to these infrared and radio frequency signals by asserting mute signal **105**. Like the digital signal described with respect to digital input signal port **112**, the infrared and radio frequency signals may range from single bit implementations that merely switch on the mute signal **105** to more complex implementations capable of conveying additional information including the caller's identity or phone number to enable the control system to make "smart" decisions about generating mute signal **105** such as caller dependent muting. In the case of infrared, the depicted embodiment of cell phone **120** produces an infrared signal **126** when the phone **120** is ringing or otherwise announcing an incoming call. Infrared signal **126** is transmitted to an infrared receiver **124** that is connected to or integrated within input port **116**. Analogously in the case of a radio frequency signal such as a Bluetooth or WiFi signal, phone **120** generates a radio frequency signal **129** that is detected by a control system antenna **128**.

In any of the implementations represented by digital signal input port **112**, infrared signal input port **116**, or radio frequency signal input port **118**, the control system **110** is configured to monitor or check the status of the signal that caused the assertion of mute signal **105**. When this signal is detected as being de-asserted or terminated, one embodiment of control system **110** resumes the audio system volume that was playing prior to being muted. In the case of audio signal input port **114**, however, the mute signal **105** may be asserted until deactivated by the user following an incoming call because the cell phone **120** may not be capable of generating a sound at the end of the phone call.

Any of the implementations represented by digital signal input port **112**, infrared signal input port **116**, or radio frequency signal input port **118**, may be used in conjunction with user-selectable phone number preferences that specify which cell phones are authorized to initiate the

automated audio system muting functions described herein. In these embodiments, the user would likely enter a setup mode of control system **110** through the audio system keypad. While in the setup mode, the user would then specify one or more phone numbers that are authorized to initiate the automated muting. In these embodiments, control system **110** would verify the identity of the cell phone being called prior to initiating the call muting process.

In another embodiment, control system **110** is configured to detect an incoming phone call directly. In one such embodiment, a user is able to indicate one or more cell phones authorized to perform the auto muting, possibly using the existing set of keys on the audio system itself. When a signal transmitted by a wireless service provider and indicating an incoming call is detected by cell phone **120**, the transmitted signal is simultaneously detected by control system **110** either through its local antenna **128** or through the external antenna **131** of the motor vehicle **100**, to which the control system is coupled. This direct detection implementation offers improved performance over the other implementations because the detection of the incoming call by the cell phone **120** occurs in parallel with the detecting of the incoming call by control system **110**. Moreover, by leveraging the external antenna for detecting incoming cell phone calls, this implementation may require the fewest modifications to existing audio systems hardware. In this implementation, the user would enter a setup mode using the audio system keypad. Within the setup mode, the user would then specify one or more cell phone numbers with which the system is concerned. When an incoming call is detected by cell phone **120**, the call is also detected by antenna **128** or **131** and processed to determine whether to mute the audio system or not.

Turning now to FIGs 2 and 3, a circuit diagram and logic diagram respectively of a control system **210** and **310** are shown to emphasize additional details of the present invention. The depicted embodiment of control system **210** includes a keypad **212** and a set of keys **214** that enable the user to provide input (such as a set of recognized or authorized cell phone numbers) to control system **210**. An interface logic unit **220** includes ports **222**, **224**, **226**, and **228** for receiving a digital input signal, an infrared input signal from an infrared receiver **124**, an output of a DSP **201**, and an output from keypad **212**. DSP **201** includes ports **202**, **204**, and **206** for receiving signals via an external antenna **131**, an audio input **114**, and an internal antenna **206**. DSP **201** is configured to process received signals and to provide a digital output signal derived from the received signal. The DSP output signal is provide to interface unit **220**. A controller

230 is connected to interface **220** and is designed to determine which, if any, of the information received by interface **220** results in the assertion of mute signal **105** and the resulting automated muting of the audio system. Controller **230** has access to RAM and ROM storage devices **240** and **250**. ROM **250** likely includes the code used by controller **230** to perform its basic functions. RAM **240** may be used to stored items such as the digital representation of a ringing phone as well as the phone numbers of authorized users of the system.

As shown in FIG 3, an embodiment of a control system **310** suitable for use as control system **110** of FIG 1 is shown to illustrate the control system's functional behavior. In the depicted embodiment, a DSP **312** of control system **310** is configured to receive "current" or live signals represented by reference numeral **318** as well as reference signals, which may have been previously learned by the system and stored in memory. DSP **312** processes the set of live signals **318** to produce digital values that are provided to a comparator **320** and possibly to a memory unit **330** (for later use). Comparator **320** determines whether there is a match between current signals **318** and reference signals **314** and provides the outcome of its determination to decision logic **340**. The decision logic then determines whether to assert the mute signal in response to a detected match between current signals **318** and reference signals **314**.

It will be apparent to those skilled in the art having the benefit of this disclosure that the present invention contemplates an audio system that responds to selected incoming phone calls as described. It is understood that the form of the invention shown and described in the detailed description and the drawings are to be taken merely as presently preferred examples. It is intended that the following claims be interpreted broadly to embrace all the variations of the preferred embodiments disclosed.